



Death in the line of duty...

A Summary of a NIOSH fire fighter fatality investigation

July 23, 2003

Fire Fighter Suffers Fatal Heart Attack At Fire Scene - Wisconsin

SUMMARY

On November 2, 2001, a 62-year-old male volunteer fire fighter collapsed at the scene of a vehicle fire as he was bringing a tool to the Chief. Despite immediate cardiopulmonary resuscitation at the scene and subsequent advanced life support in the ambulance and at the hospital emergency department, the fire fighter died. The autopsy showed “severe coronary atherosclerosis,” and the pathologist attributed death to “acute coronary thrombosis with ischemic arrhythmia.” The death certificate, completed by a deputy county medical examiner, listed “cardiac arrhythmia” as the immediate cause of death and “CAD” (coronary artery disease) as the underlying cause.

The following recommendations address some general health and safety issues identified during this investigation. This list includes some preventive measures that have been recommended by other agencies to reduce the risk of on-the-job heart attacks and sudden cardiac arrest among fire fighters. These selected recommendations have not been evaluated by NIOSH, but they represent published research or consensus votes of technical committees of the National Fire Protection Association (NFPA) or fire service labor/management groups.

- *Institute preplacement and periodic medical evaluations. These should incorporate exercise stress testing, depending on the fire fighter’s age and coronary artery disease risk factors.*
- *Fire fighters should be cleared for duty and for respirator use by a physician knowledgeable about the physical demands of fire fighting, the personal protective equipment used by fire fighters, and the various components of NFPA 1582, the*

National Fire Protection Association’s Standard on Medical Requirements for Fire Fighters and Information for Fire Department Physicians.

- *Phase in a mandatory wellness/fitness program for fire fighters to reduce risk factors for cardiovascular disease and improve cardiovascular capacity.*
- *Consider including an automatic external defibrillator as part of the basic life support equipment for fire department vehicles.*

INTRODUCTION & METHODS

On November 2, 2001, a 62-year-old male fire fighter died after collapsing at the scene of a vehicle fire. On November 6, 2001, the United States Fire Administration notified NIOSH of the death. On December 3, 2001, NIOSH contacted the affected Fire Department to initiate the investigation. On April 18, 2002, a NIOSH contract physician traveled to Wisconsin to conduct an on-site investigation of the incident.

The **Fire Fighter Fatality Investigation and Prevention Program** is conducted by the National Institute for Occupational Safety and Health (NIOSH). The purpose of the program is to determine factors that cause or contribute to fire fighter deaths suffered in the line of duty. Identification of causal and contributing factors enable researchers and safety specialists to develop strategies for preventing future similar incidents. The program does not seek to determine fault or place blame on fire departments or individual fire fighters. To request additional copies of this report (specify the case number shown in the shield above), other fatality investigation reports, or further information, visit the Program Website at www.cdc.gov/niosh/firehome.html or call toll free 1-800-35-NIOSH



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People interviewed included the

- Fire Chief
- Crew members on duty with the deceased fire fighter
- Deceased fire fighter's spouse
- Deceased fire fighter's primary care physician

Documents reviewed included the

- Fire Department operating guidelines
- Deceased fire fighter's training records
- Deceased fire fighter's medical records
- Ambulance response reports
- Hospital emergency department records
- Fire Department incident reports
- Death certificate
- Autopsy report

INVESTIGATIVE RESULTS

Incident. On November 2, 2001, the affected fire fighter responded to a vehicle fire call received at 1403 hours. He reported to the fire station and, with another fire fighter as a passenger, drove the "brush truck" (a general utility truck) to the scene, arriving at about 1420 hours. An on-duty sheriff's deputy (who is also a fire fighter with the Department) had already come to the scene in his patrol car. Another fire fighter had also already arrived, having been instructed by the Chief to go the scene in the town road maintenance vehicle he was driving as part of his regular job. The Chief had instructed the fire fighters not to attempt to fight the fire until the engine arrived; the Chief and another fire fighter arrived in the engine a couple of minutes after the brush truck. Two fire fighters (not including the affected fire fighter) began fire suppression activities. The Chief, intending to approach the burning vehicle, began putting on his self-contained breathing apparatus (SCBA) and designated the affected fire fighter Incident Commander. At about 1430 hours, the affected fire fighter got a Halligan bar from a rear compartment in the engine. As he walked toward the front of the

engine (where the Chief was), he fell forward, striking his face on the ground, and then didn't move. He neither said anything before he fell nor indicated any distress. The Chief rolled him over, saw that he was not breathing, and summoned one of the fire fighters at the burning vehicle. This fire fighter, who was an emergency medical technician (EMT), found the collapsed fire fighter pulseless and cyanotic (blue), with fixed, dilated pupils. With the Chief assisting, he started cardiopulmonary resuscitation (CPR); this occurred within a minute of the affected fire fighter's collapse.

An ambulance and advanced life support (ALS) backup were called after the fire fighter collapsed; the ambulance (which routinely responds to structural fires but not vehicle fires) arrived at about 1445 hours. An automatic external defibrillator (AED) advised a shock, which was administered. No pulse resulted, and the AED did not advise a second shock. An esophageal tracheal combitube was placed, oxygen was administered, and CPR was continued. The ambulance, staffed by basic-level EMTs (including the fire fighter who started CPR), departed the scene at 1552 hours and was intercepted by the ALS team (intermediate-level EMTs) a minute or two later. A defibrillation shock was administered, as was another 10 minutes later; neither restored a heartbeat. An attempt to establish intravenous access was unsuccessful. The ambulance arrived at the hospital at 1510 hours. An electrocardiogram (ECG) showed no heartbeat (asystole). CPR continued, intravenous epinephrine and atropine were administered (without effect), and the combitube was replaced with an endotracheal tube. Because a small baseline variation in lead II of the ECG might have represented fine ventricular fibrillation, another defibrillation shock was administered; it produced no heartbeat. Further attempts at resuscitation were considered futile, and the fire fighter was pronounced dead at 1528 hours.

The affected fire fighter had stayed in the vicinity of the brush truck and engine (motor running), which



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were parked about 100 feet upwind from the fire, where he reportedly had no smoke exposure. He wore a turnout coat, helmet, safety shoes, and leather gloves, but not turnout pants or boots. His tasks did not require a respirator. The temperature was relatively mild, and he did not engage in any physically strenuous tasks. On the day of the fire, he attended to town and church business matters and visited family members. He neither mentioned any symptoms nor showed any sign of distress during this time, at the fire station, on the way to the fire, or at the fire scene. This was his first fire call in a month.

Medical Findings. Final anatomic diagnoses listed in the report of the autopsy, which was performed by a pathologist at a hospital in a nearby city, were

- Severe three-vessel coronary atherosclerosis.
 - Multiple 90-98% stenosis of LAD [left anterior descending] and left circumflex [coronary arteries].
 - Acute thrombosis, left circumflex artery.
 - Interstitial and perivascular fibrosis, myocardium.
- Cardiomegaly due to left ventricular hypertrophy.”

The pathologist interpreted these findings as “severe coronary atherosclerosis with multiple critical stenoses” and concluded that the fire fighter had “a sudden cardiac death, due to acute coronary thrombosis with ischemic arrhythmia.” The death certificate, completed by a deputy medical examiner, listed “[cardiac arrhythmia]” as the immediate cause of death and “CAD” (coronary artery disease) as the underlying cause. A blood specimen obtained at autopsy contained “<1%” COHb. (With 45 minutes of pre-mortem oxygen administration, and a COHb half-life of 80 minutes at 100% oxygen,¹ the fire fighter’s COHb level when he collapsed would have been less than 2%, which is not indicative of medically significant CO exposure.)

The deceased fire fighter had worked for the local telephone company, the last 10 years as a lineman. He retired in February 2001. He never smoked cigarettes and in recent years was not exposed to cigarette smoke at home. His father had a heart attack at age 59 and a fatal heart attack at age 63. A sister had angioplasty at age 58. He had long-standing hypertension (high blood pressure), and low HDL-cholesterol was diagnosed a year before his death. In September 2000, the fire fighter was evaluated for chest pain; cardiac catheterization documented CAD, and he underwent coronary angioplasty. An electrocardiogram (ECG) a day after his angioplasty in September 2000 was normal. An exercise stress test (EST) in January 2001 terminated after 12½ minutes because of fatigue, showed no ECG abnormalities, and elicited no angina. An exertion level of 13 metabolic equivalents (MET) and a heart rate of 115 beats per minute (72% of maximal predicted) were achieved. These results were interpreted as negative for ischemia but with reduced sensitivity because of the sub-optimal heart rate response. A concurrent myocardial perfusion scan with gated single photon emission computerized tomography (SPECT) showed improvement over the pre-angioplasty scan, with a smaller area of inferior lateral wall ischemia; the ejection fraction and wall motion were normal.

After his angioplasty, the affected fire fighter walked 2 miles every day; in inclement weather he used a treadmill or exercise bicycle at home. He did house and yard work and trimmed trees at his Christmas tree farm, most recently the day before his death. Since his angioplasty, he tired more easily. His cardiologist attributed this to blood pressure medicine (a beta-blocker) and in July 2001 discontinued the drug. Although the fire fighter never reported symptoms of CAD to his family or colleagues, he did tell his primary physician and his cardiologist that he had chest discomfort with exertion. At the time of his death, his prescribed medications included niacin

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for his cholesterol, a nitrate and aspirin for his CAD, and nitroglycerin when needed for angina (heart pain).

At his last visit to his physician, in October 2001, his blood pressure was 142/78 mm Hg. His weight at that time was 167 pounds. With a height of 70 inches, his body mass index (BMI) was 24 kg/m², indicating that he was not overweight.²

DESCRIPTION OF THE FIRE DEPARTMENT

At the time of the site visit, the Fire Department had 23 volunteer fire fighters; a full roster is 31. The Department serves an unincorporated rural area of 90 square miles with a population of 18,000. There is one fire station. In 2001, the Department responded to 31 calls. A county-owned ambulance, housed at the fire station, is operated by the hospital in the county seat and staffed by community volunteers. The Fire Department is not responsible for responding to medical calls, but it provides assistance to the emergency medical service if needed.

Training. Fire Fighter I training (but not certification) is currently required before a new fire fighter can engage in fire fighting, but this person can engage in support activities before the training is completed. The deceased fire fighter had been a volunteer fire fighter since the department was founded in 1966. He had completed Fire Fighter I (and some II) training and had additional training or experience (if not formal certification) in fire investigation, incident command, wildland fire fighting, apparatus driving and operation, first aid, CPR, and search and rescue.

Medical Evaluations. The Department has no preplacement or periodic medical evaluations or physical agility tests. Medical clearance is not required for respirator use or for returning to duty after an injury or illness. Members who are unable to perform a full range of duties due to health problems or age,

however, are accommodated by limiting their tasks to those they are able to do. The department has no health promotion programs or exercise/fitness equipment.

DISCUSSION

In the United States, coronary artery disease (atherosclerosis) is the most common risk factor for cardiac arrest and sudden cardiac death.³ Risk factors for its development include increasing age, male gender, heredity, tobacco smoke, high blood cholesterol, high blood pressure, physical inactivity, obesity/overweight, and diabetes.⁴ In addition to age and gender, the deceased fire fighter had three of these risk factors (family history, high blood pressure, and a cholesterol abnormality).

The narrowing of the coronary arteries by atherosclerotic plaques occurs over many years, typically decades.⁵ However, the growth of these plaques probably occurs in a nonlinear, often abrupt fashion.⁶ Heart attacks typically occur with the sudden development of complete blockage (occlusion) in one or more coronary arteries that have not developed a collateral blood supply.⁷ This sudden blockage is primarily due to blood clots (thrombosis) forming on top of atherosclerotic plaques. On autopsy, the deceased fire fighter had an acute thrombosis of a coronary artery. Sudden cardiac death is often the first overt manifestation of ischemic heart disease.⁸ The deceased fire fighter had well-documented CAD, and autopsy findings (perivascular and interstitial fibrosis in the myocardium [heart muscle]) were consistent with ischemic heart disease.

Blood clots, or thrombus formation, in coronary arteries is initiated by disruption of atherosclerotic plaques. Certain characteristics of the plaques (size, composition of the cap and core, presence of a local inflammatory process) predispose the plaque to

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disruption.⁷ Disruption then occurs from biomechanical and hemodynamic forces, such as increased blood pressure, increased heart rate, increased catecholamines, and shear forces, which occur during heavy exercise.^{9,10}

Fire fighting is widely acknowledged to be one of the most physically demanding and hazardous of all civilian occupations.¹¹ Fire fighting activities are strenuous and often require fire fighters to work at near maximal heart rates for long periods. The increase in heart rate has been shown to begin with responding to the initial alarm and persist through the course of fire suppression activities.¹²⁻¹⁴ Epidemiologic studies have found that heavy physical exertion sometimes immediately precedes and triggers the onset of acute heart attacks.¹⁵⁻¹⁹ The deceased fire fighter drove a vehicle to the fire scene. Once there, he did not engage in any activity more physically strenuous than walking a short distance carrying a hand tool while wearing a turnout coat (but no other heavy gear). His routine daily activities exceeded this level of exertion. However, the extent to which responding to the alarm and driving to the scene increased his heart rate and blood pressure, and thus his cardiac oxygen demand, is unknown.

NFPA 1582, the National Fire Protection Association's *Standard on Medical Requirements for Fire Fighters and Information for Fire Department Physicians*, considers hypertension and CAD to be Category B conditions, that is, "a medical condition that, based on its severity or degree, could preclude a person from performing as a member in a training or emergency operational environment by presenting a significant risk to the safety and health of the member or others."²⁰ The deceased fire fighter's blood pressure readings at his physicians' offices, including the most recent (without blood pressure medicine), were within the range considered acceptable by NFPA 1582 (less than 180 mm Hg systolic, less than 100 mm Hg diastolic). NFPA 1582

specifies five criteria that put someone with CAD at only "mildly increased risk for sudden incapacitation" and thus "acceptable for fire fighting." These criteria are "normal left ventricular ejection fraction," "normal exercise tolerance, >10 metabolic equivalents (METS)," "absence of exercise-induced ischemia by exercise testing," "absence of exercise-induced complex ventricular arrhythmias," and "absence of hemodynamically significant stenosis of all major coronary vessels (<50 percent lumen diameter narrowing), or successful myocardial revascularization." The deceased fire fighter met the first four criteria but not the fifth. His cardiac catheterization showed narrowing of 50% or more in multiple arteries, one of which, the most severely affected, was then treated by angioplasty.

NFPA 1582 considers "angina pectoris, current" a Category A condition, that is, "a medical condition that would preclude a person from performing as a member in a training or emergency operational environment by presenting a significant risk to the safety and health of the member or others." Given the deceased fire fighter's CAD status (angina with use of nitroglycerin, ischemia demonstrated by myocardial perfusion scan during EST), he would presumably not have been medically cleared for **full** fire fighting duties if NFPA 1582 were followed. At the time of his death, however, he was not expected to perform physically strenuous tasks at the fire scene, nor was he doing so. A fitness-for-duty medical evaluation consistent with NFPA 1582 would not necessarily have excluded him from such limited duty.

RECOMMENDATIONS

The following recommendations address health and safety issues identified during this investigation. This list includes some preventive measures that have been recommended by other agencies to reduce the risk of on-the-job cardiac arrest among fire fighters. These

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selected recommendations have not been evaluated by NIOSH, but they represent published research or consensus votes of Technical Committees of the National Fire Protection Association or fire service labor/management groups.

Recommendation #1. Institute preplacement and periodic medical evaluations. These should incorporate exercise stress testing, depending on the fire fighter's age and coronary artery disease risk factors.

The purpose of medical evaluations is to ensure that fire fighters have the ability to perform duties without presenting a significant risk to the safety and health of themselves or others. Guidance regarding the content and scheduling of medical examinations for fire fighters can be found in NFPA 1582.²⁰ In addition to providing guidance on the frequency and content of the medical evaluation, NFPA 1582 provides guidance on medical requirements for persons performing fire fighting tasks. After the preplacement evaluation, NFPA 1582 recommends a limited annual evaluation, including a medical and occupational history and a limited physical examination (height, weight, blood pressure, heart rate and rhythm). In addition, NFPA 1582 recommends a more extensive medical evaluation at an interval of 1 to 3 years, depending on the fire fighter's age. NFPA 1582 recommends that periodic exercise stress testing (EST) begin at age 35 for those with CAD risk factors and at age 40 for those without CAD risk factors. Other expert groups, however, do not recommend EST for asymptomatic individuals without risk factors for CAD, although they acknowledge that such screening might be appropriate for persons in occupations affecting public safety.^{21,22}

Applying NFPA 1582 involves legal and economic issues, so it should be carried out in a **confidential, nondiscriminatory** manner. Appendix D of NFPA 1582 provides guidance for fire department

administrators regarding legal considerations in applying the standard. The economic concerns go beyond the costs of administering the medical program; they involve the personal and economic costs of dealing with the medical evaluation results. NFPA 1500, *Standard on Fire Department Occupational Safety and Health Program*, addresses these issues in Chapter 8-7.1 and 8-7.2.²³ The success of medical programs hinges on protecting the affected fire fighter. The department must (1) keep the medical records confidential, (2) provide alternate duty positions for fire fighters in rehabilitation programs, and (3) if the fire fighter is not medically qualified to return to active fire fighting duties, provide permanent alternate duty positions or other supportive and/or compensated alternatives. (For safety reasons, driving fire department vehicles may not be an acceptable alternate duty job for someone with work-limiting CAD.) Unfortunately, the second and third requirements may not be workable in a volunteer department and could thus impair both acceptance by fire fighters and the fire department's ability to recruit and retain fire fighters. On the other hand, the Fire Department described in this report already provides alternative duty, albeit informally and without medical oversight.

Applying this recommendation involves economic repercussions and may be particularly difficult for small, rural, volunteer fire departments to implement. To overcome the financial obstacle, the Fire Department could urge current members to get annual medical clearances from their private physicians (but see Recommendation #2). Another option is having the brief annual medical evaluations recommended by NFPA 1582 completed by the volunteer fire fighters themselves (medical and occupational history) and by EMTs from the county's EMS (vital signs, height, weight, and visual acuity). This information could then be provided to a community physician, perhaps volunteering his or her time, to review the data and provide medical



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clearance (or further evaluation, if needed). The more extensive periodic medical examinations could be performed by a private physician at the fire fighter's expense, provided by a physician volunteer, or paid for by the Fire Department. Sharing the financial responsibility for these evaluations between volunteers, the Fire Department, and willing physician volunteers should reduce the negative financial impact on recruiting and retaining needed volunteers.

Recommendation #2: Fire fighters should be cleared for duty and for respirator use by a physician knowledgeable about the physical demands of fire fighting, the personal protective equipment used by fire fighters, and the various components of NFPA 1582, the National Fire Protection Association's Standard on Medical Requirements for Fire Fighters and Information for Fire Department Physicians.

The decision regarding medical clearance for fire fighters requires knowledge not only of the fire fighter's medical condition, but also of the fire fighter's job duties and NFPA 1582 medical fitness criteria. NFPA 1582 recommends that return-to-duty evaluations (after an injury or illness) be done by the "fire department physician."²⁰ As part of the return-to-duty evaluation, the fire department physician should review relevant records from the fire fighter's personal physicians and/or discuss with them the fire fighter's illness or injury.

The Occupational Safety and Health Administration (OSHA) respiratory protection standard²⁴ requires employers whose employees are required to use respirators to have a formal respiratory protection program, including periodic medical evaluations. Since Wisconsin does not have an OSHA-approved State plan, public employers, including volunteer fire departments, are not legally subject to OSHA standards.²⁵ Nevertheless, we recommend that the Fire Department voluntarily adhere to the health- and

safety-related provisions of the OSHA standard, including periodic medical evaluations. The medical evaluations for respirator use can be done at the same time as fitness-for-duty examinations, and often they do not involve substantial additional evaluation. (Pulmonary function testing [PFT] may be useful for evaluating respiratory symptoms or physical examination findings, but it is otherwise not needed routinely for a respirator clearance evaluation. NFPA 1582 does not require PFT as part of the limited annual medical evaluation.²⁰)

Recommendation #3: Phase in a mandatory wellness/fitness program for fire fighters to reduce risk factors for cardiovascular disease and improve cardiovascular capacity.

NFPA 1500, *Standard on Fire Department Occupational Safety and Health Program*, requires a wellness program that provides health promotion activities for preventing health problems and enhancing overall well-being.²³ The International Association of Fire Fighters (IAFF) and the International Association of Fire Chiefs (IAFC) joined in a comprehensive Fire Service Joint Labor Management Wellness/Fitness Initiative to improve fire fighter quality of life and maintain physical and mental capabilities of fire fighters. Ten fire departments across the United States joined this effort to pool information about their physical fitness programs and to create a practical fire service program. They produced a manual and a video detailing elements of such a program.²⁶ The Wellness/Fitness Initiative provides guidance regarding wellness program content to include physical examination and evaluation, fitness, and behavioral health. Wellness programs have been shown to be cost-effective, typically by reducing the number of work-related injuries and lost work days.^{27, 28} An unpublished analysis by the Phoenix, Arizona, city auditor found a reduction in disability pension costs following a 12-year commitment to the wellness

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program at the Fire Department. Small volunteer fire departments should review the programs mentioned above and determine which components are practical for them.

Recommendation #4: Consider including an automatic external defibrillator as part of the basic life support equipment for fire department vehicles.

Although the Fire Department does not have medical first responder responsibilities, fire fighters may find themselves in the position of having to provide CPR. The timely use of an automatic external defibrillator, even by minimally trained first responders, can increase the likelihood of survival following cardiac arrest.^{29, 30}

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INVESTIGATOR INFORMATION

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